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FIELD INVESTIGATIONS PRELIMINARY TO
LIFE HISTORY STUDIES ON THE
LITHOSINA-MIONA-CASTA COMPLEX
OF THE GENUS ANNAPHILA (NOCTUIDAE)

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THE FAMILIARIZATION OF THE SPECIFIC HOST PLANT adaptations of the Genus *Annaphila* by the author of this paper, as well as by other field observers over a period of several years, offered evidence of the possibility that the published statement in Rindge and Smith's revision, to the effect that the larvae of *Annaphila lithosina* Grt., are predaceous, was considered by many as highly problematical, (as noted by J. S. Buckett in a recent publication) and was considered as worthy of further investigation.

It had been observed by numerous field workers who have collected the adults of this species (Bauer, Buckett, Leuschner, Sala, Henne and others) that the moths were generally taken in close proximity to masses of boulder outcroppings with shaded or damp conditions, and often with a small stream or seepage in the immediate area. Typical of the flight pattern of most of the members of this genus, specimens are netted when on the wing with difficulty and require extreme dexterity as stated by Frank Sala in his article on "The Difficulty of Collecting *Annaphila*" (Sala 196-). The rapid flight is somewhat curtailed by temperature extremes, becoming lethargic during a sudden drop in temperature or seeking shade during an exceptionally hot day. The visiting of available flowers near their habitat occurs during ideal weather conditions and oviposition also requires similar conditions and usually results in an opportunity for the field observer to determine the specific host plant of the species.

Until recently attempts at observing females of *lithosina* ovipositing in the field proved unsuccessful.

A partial list of a few of the localities familiar to the author where this species occurs, and the conditions in which specimens were collected, are as follows, beginning with the most southern (as far as known) extent of its range:

1. Kern River Cyn., Greenhorn Mts., Kern Co., Calif. el. 1200' & 2200' (Leuschner, Sala, Henne) specimens taken in flight and resting.
2. E. Kaweah River (Mineral King Rd.), Tulare Co., Calif., el. 2200' (Henne) collected in flight and visiting *Montia* and *Gilia* flowers. Same locality at 3200' el. (D. Henne) collected while visiting moisture.
3. Del Puerto Cyn., Stanislaus Co., Calif., (Longford, Powell).
4. 3 mi. E. Auburn, El Dorado Co., Calif., el. 1000', one adult in flight collected (Bauer, Buckett, Gardner).

We did not have a clue during this interval as to the plant association of *lithosina*, although Bauer, Buckett and Henne concluded that it was a plant typical of damp, rocky invironments, an ecology observed in the localities where the adults have been taken.

An important field observation was then made by Oakley Shields, while carrying on *Mimulus* research at the Carnegie Experimental Gardens at Mather, Tuolumne Co., Calif., el. 4600'. In a marshy meadow adjoining the "Gardens" he observed a female *Annaphila miona* Sm. ovipositing on *Mimulus moschatus* Dougl. The author of this paper had collected a series of this species in the area a few days before and confined females, with a selection of the plants that seemingly offered the best possibilities of including the specific food plant, but the females failed to oviposit. Unfortunately, weather conditions prevented further field research at that time. Shortly after returning to Southern California a Special Delivery letter was received from Oakley Shields describing his observations. This was the first tangible observation we had been able to acquire on the plant association of the closely allied species *lithosina*, *miona* and *casta*.

Although it was not possible to return to Mather for further studies on *miona* following Shield's report, the author devoted a considerable amount of time the following year in studying the plant ecology of various localities in which *lithosina* had been recorded. The two Kern Canyon localities were searched for members of the *Mimulus* group. A species of perennial *Diplacus* was found in the shade of the huge boulders where *lithosina* adults had previously been taken. An examination of the young growth did not produce ova or signs of larval feeding and there were no adults observed on the wing at that time. The leaf structure of *Diplacus* is generally viscous and hard, particularly when

the plant is exposed to the sun's rays and the flower budding period is late, but the terminal leaf growth or buds in a shaded environment could possibly accommodate the young larvae. A further search for moisture inhabiting species of *Mimulus* in the area was unsuccessful, and not too probable, due to the usual rushing torrent of the Kern River. Further field research in this locality might prove *Diplacus* to be one of the established larval host plants. Note: *Diplacus* is placed in the Genus *Mimulus* in some botanical literature.

The next locality visited was the E. Kaweah River on the Mineral King Road, where both *Diplacus* and *Mimulus guttatus* occurs, and where, as previously stated, adult specimens of *lithosina* had been taken. Both *Diplacus* and *Mimulus* plants were examined for ova at various elevations. A few *Annaphila* spp. were observed on the wing, but they were not accurately identified. However, as a clump of *Mimulus* growing on a damp, rocky outcropping at the side of the road was approached in the vehicle, an *Annaphila* was flushed, and it was quite obviously a female *lithosina*. The plants were examined and three ova were found under the terminal leaves. Unfortunately, the resultant young larvae were lost during the extended field trip.

Personal communication with Dr. Jerry Powell on the plant ecology in Del Puerto Canyon, where a series of *lithosina* contained in the University of California Collection at Berkeley were collected, established the fact that *Diplacus* was observed near where the specimens were taken. A casual survey by the author in this area failed to locate any stream or moisture inhabiting species of *Mimulus*.

The primary purpose of the field trip to northern California was to attempt, not only to determine the life history of *lithosina* but also that of the closely related *castas*. Coincidentally, Wm. Bauer and J. S. Buckett were fortunate in arriving at a locality near the American River, 3.5 mi. E. of Auburn at the height of the adult emergence of *Annaphila lithosina*, which made possible the excellent ecological paper by Buckett (Buckett, 1966).

Thanks to their cooperation, the author was notified of the *lithosina* flight and availability of ova on *Mimulus guttatus*. Fisch. This locality was familiar to all of us from a previous scouting trip made the year before, at which time in comparing a typical terrain with other localities in which *lithosina* occurred, this locality offered possibilities for future success. Later that same year Bauer and Buckett collected a single specimen here. A subsequent report by a student entomology major divulged another colony,

15 mi. N. E. of Auburn, Placer Co., California. The following year the author and his wife found still another colony 6 mi. E. of Auburn, Placer Co., Calif., where ova were collected. These supplied additional specimens which will be utilized in future life history studies presently being illustrated in full by John A. Comstock.

J. S. Buckett is also planning further studies in this group on taxonomic details, including setal maps; further observations on their ecology, and possibly the discovery of a key to the origin of their relationship.

In a recent letter from Wm. H. Evans, who has also contributed a great deal of valuable knowledge to this genus of moths, he stated that he had listed *Mimulus* as a possible foodplant several years ago but discounted the possibility, due to the late blooming period, as most of the other species of this Genus feed exclusively on the buds and flowers.

It appears that *lithosina* has only been reported in the southern part of its range in early April; early May in the vicinity of the American River, and the latter part of June in Plumas Co. Further field research should determine whether the adult emergence coincides with the plant growth or is dependent upon variations in weather conditions, or both.

A possible explanation for the erroneous statement that the larvae of *lithosina* are predaceous, might stem from the fact that Prof. Harry S. Smith in collecting early stage wasp material at Sacramento on February 16, 1915 may have located the galleries in partially decomposed wood (stump or log). There are numerous species of Microlepidoptera larvae that feed upon the wax combs or pollen packs of Hymenopterous insects, and it is possible one of the predaceous species of Micros might exist in a habitat of this type, or another supposition might be that the larvae could also have belonged to a known species of predator representing a different Order of insects. A larva of *lithosina*, if there was a colony nearby, possibly entered the wood in close proximity to the wasp galleries, and Professor Smith assumed that the larvae he observed were of the same species. It was discovered during the laboratory rearing that *lithosina* larvae enter available partially decomposed wood and form their pupal cells therein.

Several attempts were made by the author to determine the host plant of the little known species, *Annaphilla casta*. Hy Edw. The few known records at the time for the occurrence of the adults, as stated by J. S. Buckett, and its restricted range contributed to the difficulty of visualizing a tangible habitat.

The possible clarification of Walshingham's type locality (Camp 9), by J. S. Buckett, led to an investigation of the area and adjoining Oakland, Douglas Co., Oregon in May, 1965. A lumber mill had depleted the natural growth throughout the immediate area and no likely spot where *casta* might occur was found. However, a more thorough survey with more time allowed, could most likely produce a more acceptable habitat for this species, particularly between this area and the coast.

The next investigation on this field trip was made to the McDonald Forest, N.W. Corvallis, Benton Co., Oregon in the company of Stephen Perkins. Through the cooperation of Dean Shumway, Biologist in charge, and following records of two adults of *casta* taken by Noel McFarland in 1963, a likely habitat was found within the Forest, where *Annaphila diva* occurred commonly visiting the flowers of a *Montia* sp. and also ovipositing on the same plant. Many specimens of this species were taken on the wing by Henne and Perkins and upon examination three specimens were found to be *casta*, which were difficult to distinguish on the wing from *diva* except for their larger size. Two more examples were observed by the author, which were assumed to be this species, hovering over a marshy glade surrounded by tall conifers, but unfortunately they avoided capture. Later knowledge of this species would undoubtedly have proved that the specific larval host plant occurs here in this type of habitat, and the specimens observed were females in ovipositing action.

Another locality that offered possibilities for the establishment of a colony was in the Coast Range, west of Portland, Oregon but no adults were observed by Perkins or Henne.

Plans to return to Oregon for further field research on *casta* were postponed when it was learned through Wm. Bauer and J. S. Buckett that Noel LaDue had taken specimens of *casta* at Plantation, Sonoma Co., California. This information was followed by intensive field work in this area by Henne, Bauer, Buckett and Gardner. Several adult females were taken by Bauer and Buckett in 1965 but on a return trip by all of us a few days later no specimens were seen. The many species of plants examined did not produce any early stage material.

The following year the author and his wife returned to this locality and one female *casta* was netted by D. Henne alighting on a small *Diplacus* bush at the edge of the marshy meadow.

A return trip to Plantation in May, 1967 proved to be far more productive. Prior to this Oakley Shields had determined the host plant of the closely related *Annaphila miona*, as stated previ-

ously, which was of great assistance in tracing the possible host plant of *casta*. The ecology of the few known localities where this species occurs was beginning to display a more comprehensive picture, as the Plantation locality was comparable to the McDonald Forest area and also ties in with Walshingham's description of a "clearing in the redwoods".

The author and his wife arrived at the Plantation locality on May 15, 1967 and stationed themselves at strategic observation points at either end of the marshy meadow. This habitat is surrounded by tall, second growth redwoods (*Sequoia sempervirens*). Other trees include Madrone (*Arbutus menziesii*), Tanbark Oak (*Lithocarpus densiflora*), and *Ceanothus*. The predominant low vegetation consists of *Carex*, *Stachys*, *Iris*, *Diplacus*, *Mimulus*, *Dentaria*, *Trillium* and an unidentified low-growing, flowering perennial. There is a considerable amount of partially decayed, fallen redwood trunks and branches and first-growth stumps from past lumbering operations. Part of the meadow contains shallow water where *Stachys*, *Mimulus* and *Carex* predominate.

The day was sunny with a slight westerly breeze. The meadows do not receive the full sun until mid-morning, and the first adult activity of *Annaphila casta* did not occur until around 11:30 A.M. when one female was seen flying slowly low over the meadow and alighting periodically on *Carex* stems or dry vegetation with wing action typical of the Genus. This specimen was netted and placed alive in a screened container with the "presumed food-plant", a slimy-leaved, marsh inhabiting *Mimulus*, later identified as *Mimulus mochatatus* Dougl. Between noon and 12:45 P.M., ten more females were taken — all in fresh condition. Their flight pattern was similar to the first specimen collected and they were always in close association with young *Mimulus* plants. No females were actually observed in the act of oviposition, but upon examination of many young plants, 20 ova were found on the underside of the leaves that without much doubt were those of *casta*. The confined female laid three ova at random, probably due to artificial and disturbing conditions when in confinement. These were compared with those taken later on the underside of the *Mimulus* leaves with the use of a hand lens and were found to be identical. Unfortunately a detailed structural study of the ova was not made at this time, but we intend to add this at a later time in a subsequent publication as well as the full descriptions and illustrations of the larva and pupa now completed by Dr.

John A. Comstock. No adults were observed visiting flowers for nectar.

Growing plants were transported to the home laboratory as well as a good supply of leafy stems which were placed in a plastic bag and later put in refrigeration. This supply remained in good condition throughout the life cycle of the larvae. Two last instar larvae were transferred to *Mimulus guttatus* (*A. lithosina* host plant as recorded by J. S. Buckett) as an experiment, and it was readily consumed, but it will be determined by further experimentation whether this substitute foodplant will be accepted by newly hatched larvae.

The question presented itself as to the method of pupation of *Annaphila casta* in its highly specialized environment. The possibility of the larvae entering the soil in a marshy area was highly improbable, as many of their host plants where eggs were found were in heavy mud or even where a shallow covering of water occurred. The entering of dried sedge (*Carex*) stems or other pulpy stems, which is an adaptation of *Annaphila depicta morula* Rindge & Smith as recorded by Wm. Evans and *A. depicta depicta* Grt. larval behavior as followed by Comstock and Henne, seemed problematical, as very little of this material was available in close proximity to the breeding grounds, or even later in the season with the possibility of the drying out of the marshy areas. The most plausible solution seemed to be that the larvae might enter the relatively soft, partially decayed, fallen trunks and branches or bark or redwood. Samples of all likely material of this type from this habitat were transported to the laboratory, and the larvae, as it was surmised, entered this medium in the rearing cages and formed pupal cells made partially with chewed wood particles cemented together similar to those formed by the *A. astrologa* B & McD group. The larvae of *lithosina* were also found to have similar habits, and with *miona* having a comparable type habitat to *casta*, this species is also presumed to have the same type of adaptation in the pupal stage.

Rindge and Smith (1965) show that the genitalia of *miona* and *casta* prove their close relationship. Further studies by Wm. Bauer and J. S. Buckett, who have contributed a great deal of important knowledge on this interesting Genus, have further substantiated the *lithosina*, *miona*, *casta* relationship.

The evolvement of this complex presents an interesting challenge for further research.

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